



DYED WATER TESTING PROCEDURES HIGH LEVEL SEWERSHED BALTIMORE CITY PROJECT 1028



The information contained in this manual is not intended to address or account for all situations or circumstances encountered, rather it provides the user with general guidelines of the procedures to be followed for Dyed Water Testing in the High Level Sewershed.



**BALTIMORE HIGH LEVEL SEWERSHED
SMOKE TESTING PROCEDURES
PROJECT #1028
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I. Dyed Water Testing

Dyed water testing is a cost-effective method of locating and quantifying sources of inflow and infiltration (I/I) in piped conveyance systems.

The principal I/I sources that may be located through dyed water testing include:

- Cracked or broken mainline sewer pipes
- Leaking manholes
- Illicit connections to sanitary sewers (downspouts, area drains, driveway drains, etc.)
- Cross-connections between storm and sanitary sewers

Dyed water testing is a technique used to determine if one or more of the above sources is contributing I/I to the sanitary sewer system. It is also a verification test of potential I/I sources that are typically identified first through manhole inspections, CCTV inspections, or smoke testing.

Different types of dyed water testing can be utilized to confirm sources of clear water in the sanitary sewer system.

Dyed Water Test

A dyed water test is used to confirm illicit connections to sanitary sewers (see Figure 1). Sources of inflow such as downspouts, area drains, window well drains, patio drains, stairwell drains, and driveway drains can be detected by smoke testing and verified through a dyed water test. It should be noted that these inflow sources may not always be identified during smoke testing due to clogged drains or trapped building service laterals. Therefore, house-to-house dye-testing surveys may be utilized in conjunction with smoke testing to locate potential illicit connections or to confirm illicit connections identified during smoke testing.

A dyed water test is conducted by placing dye tablets in the suspected source connection and flushing the connection with water to simulate flow of rainwater. If dye is observed in the sanitary sewer downstream of the suspected source, then the source has been confirmed as an improper direct connection to the sanitary sewer and a source of I/I.



Figure 1 - Illegal Downspout Connection

Flooding Dye Test

A flooding dye test is used to confirm direct or indirect connections between storm drains and sanitary sewer pipes. During smoke testing, if smoke is observed being emitted from a catch basin, storm manhole or other storm drain feature, this observation should be recorded for subsequent dye testing to verify the suspected source (see Figure 2).

A flooding dye test is conducted by flooding the suspected source with dyed water and plugging the storm pipe downstream of the source to trap the dyed water. If dye is observed in the sanitary sewer downstream of the suspected source, then the source has been confirmed as being either directly or indirectly connected to the sanitary sewer (see Figure 3).



Figure 2 - Smoke from Catch Basin Reveals Potential Connection Between Storm and Sanitary

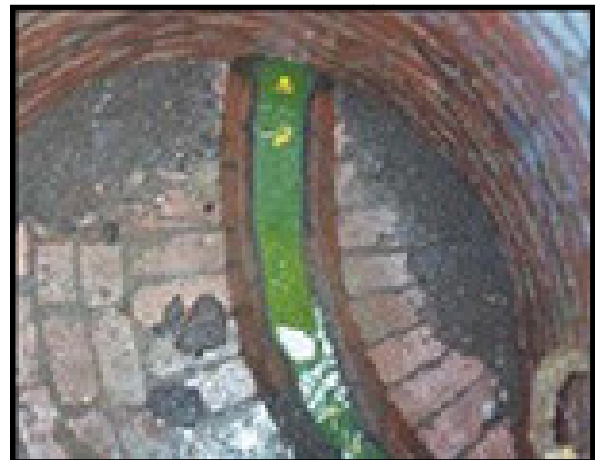
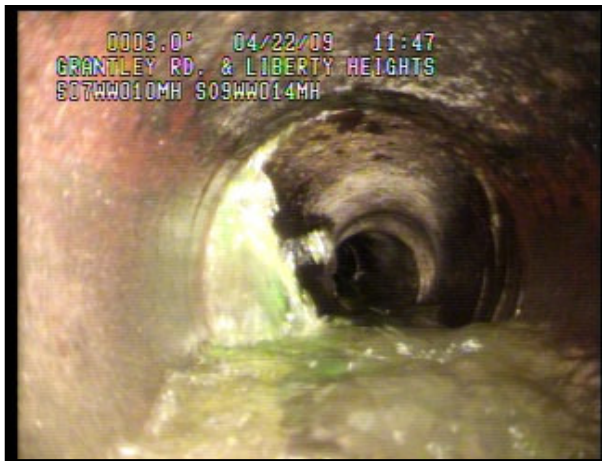


Figure 3 - Dye Visible in Downstream Sanitary MH Confirms Connection from Storm to Sanitary

Dyed Water Tracing

Dyed water tracing is typically used in conjunction with a dyed water test or flooding dye test. Dyed water tracing utilizes CCTV inspection equipment to determine the exact location where I/I is entering the sanitary sewer. After dye is observed in a downstream sanitary manhole, a CCTV camera is used to televise the sanitary sewer pipe upstream from that manhole. The CCTV inspector notes any location at which dye enters the sanitary sewer pipe through a defect (see Figures 4 and 5). Dyed water tracing provides more precise information about the source, including its exact location along the pipe segment and the quantity of I/I conveyed.



**Figure 4 - Dye Enters Sanitary from Defective Joint
Indirect Connection from Storm Drain**



**Figure 5 - Dye Enters Sanitary from Overflow Pipe
Direct Connection from Storm Drain**

II. Dyed Water Testing Notification Protocol

When access to private property is required to complete a dye test, the Subconsultant must notify the property owner at least four weeks prior to performing any dyed water testing activities. When entering private property, the Subconsultant shall make an effort to notify the property owner and identify themselves.

III. Preparation for Testing

The High Level Sewershed (HLSS) Team will provide the Subconsultant with maps of the sanitary sewer and storm drain systems for the areas to be dye tested. Dye test set-up information will be shown on the maps. These maps will include, at a minimum:

- Sanitary Sewer Pipes with Sewer ID, Flow Direction, and Pipe Size
- Sanitary Manholes with Manhole ID
- Storm Drain Pipes with Pipe Size
- Storm Manholes
- Storm Inlets

- House Connections
- Streets with Street Name
- Parcels with Address Number
- Aerial Photograph as Map Background
- Location(s) where dye should be introduced
- Locations(s) where plugs should be inserted
- Location(s) where sanitary sewer should be checked for dye (at sanitary manholes)

The field crew manager must review these maps prior to the day of testing and ask for clarification from the HLSS Team if necessary. See Appendix A for an example of a dye testing field map as provided by the HLSS Team. In particular, the field crew manager must note the diameters of the storm drains for each test set-up and ensure that the appropriate plugs are available to fit the various storm pipe sizes.

The safety of both the field crew and the general public must be considered when setting up each dye test. If sanitary or storm manholes to be opened are located within a roadway, the field crew must install the appropriate signs, barricades, or other measures to ensure proper traffic control.

When the storm manhole to be flooded is located along a busy street, two or more additional crew members may be needed to assist in moving barricades and directing traffic. All workers must wear approved safety vests at all times, both to alert drivers when they are in the street and to clearly identify all members of the crew to the public, particularly when members must enter private property. All workers must also have proper identification from the Subconsultant. The Subconsultant is responsible for providing maintenance of traffic and any permits required to complete dyed water testing.

IV. Field Procedures

The following field procedures describe the process for successful completion of a flooding dye test. This is the only type of dyed water testing used on the High Level Sewershed project.

Flooding dye tests should only be conducted on days following 2 or more consecutive days of dry weather and when the temperature is greater than 32°F.

For each test, the storm pipe(s) should be plugged as indicated on the provided field maps. Prior to inserting a plug, the field personnel must observe the flow travelling through the pipe and verify that the plug will not cause any sewer backups or discharges. In order to flood a catch basin or storm manhole, the plug is typically inserted in the incoming pipe of the nearest downstream storm manhole. The plugs are used to hold the dyed water within a specified section of storm sewer, allowing the dyed water to potentially travel to the sanitary sewer through either direct or indirect connections.

Once the plugs are inserted, the dye can be introduced into the suspected I/I source. Where possible, the nearest fire hydrant may be used as the source of water to flood the storm manhole or catch basin. Figures 6 and 7 show some of the equipment used for flooding dye tests.



Figures 6 & 7 – Flooding Dye Test Equipment

Before the dye is introduced, one crew member should be in place at the nearest sanitary manhole downstream of the storm feature to be flooded. This crew member is responsible for monitoring the flow through the manhole and identifying any dyed water. For some test locations, due to the configuration of the sanitary and storm pipes, the maps provided by the HLSS Team indicate that a second downstream sanitary manhole should be checked if dye is not observed at the first monitoring location.

The waiting period for monitoring the sanitary sewer after the introduction of dye will vary, depending on the flow characteristics of the pipes that are being tested. Monitoring should extend for at least one hour after the introduction of dye into the storm manhole or catch basin, in order for a flooding dye test to be considered negative.

As soon as dye is observed in the sanitary sewer, the CCTV inspection crew must be mobilized. The CCTV camera should be placed in the sanitary manhole where the dye was observed. The CCTV crew then shall televise upstream of the manhole where the dye was observed. The CCTV inspection must pause at any location where dye is observed entering the sanitary sewer pipe. The CCTV inspector will code each dye observation per PACP Guidelines. At the same time, another crew member should fill out the field form for the test. If the dye test setup was modified in the field, notes should be added to the field map to indicate all pertinent information about the changes. In addition, a still photo must be taken of each dye observation for use in the dye testing reports. Figures 8 through 11 show still photos of dye entering the sanitary sewer from various sources.

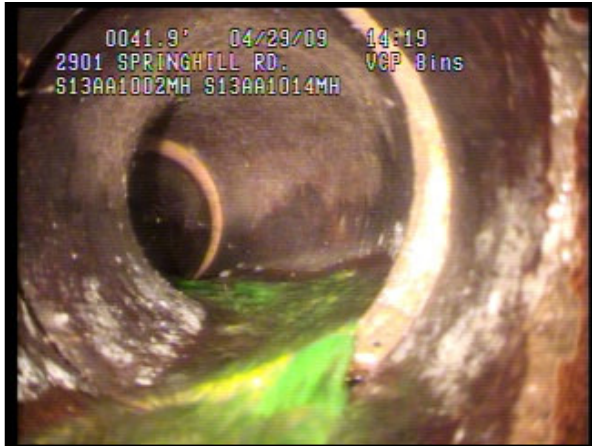


Figure 8 - Dye Enters Sanitary Sewer from Lateral



Figure 9 - Dye Leaks into Manhole from a Defect



Figure 10 - Dye Enters Sanitary from Defective Joint



Figure 11 – Dye in Pipe from Separated Joint

All dyed water testing activities must be performed in accordance with the EPA SSES Handbook and NASSCO Guidelines and shall follow sound engineering practices.

V. Dyed Water Testing Data Delivery

All field maps, field forms, notes, photographs, CCTV videos and CCTV databases that are accumulated in the field during a dye test should be compiled into a comprehensive report that includes all pertinent testing data. All photographs must be saved in digital JPEG format. All videos must be saved in MPEG 1 format and stored on CD-R discs.

All data entries on the dye testing field forms must be complete and legible. Markups of field maps, including test set-up modifications, should be neat. If any data provided by the HLSS Team on the field maps is missing or incorrect, the Subconsultant shall make note of these instances, which may include unidentified manholes, non-existent manholes, new pipe segments, abandoned pipe segments, incorrect flow arrows and any other observations needed to correctly update the maps.

All notes, photographs and findings that are accumulated in the field must be imported into the Smoke and Dyed Water Testing Database. Hand-written field data that has passed the Subconsultant's QC process will be organized and stored by the Subconsultant in the Microsoft Access database. See Appendix B for the **Users Guide for the Smoke and Dyed Water Testing Database**. This Access database was designed to facilitate the population of smoke and dye testing information, observation data, and photograph records according to the database schema and specifications outlined in the Smoke and Dyed Water Testing section of the Baltimore Sewer Evaluation Standards (BaSES) Manual (Appendix 6-6).

Dye testing data will be delivered to the HLSS Team weekly. Each delivery must include:

- Smoke and Dyed Water Testing Database, including all dye testing completed to date
- Field Forms
- Field Maps (in color)
- Photographs (divided into subfolders by date of testing)
- CCTV Videos (divided into subfolders by date of testing)
- CCTV Databases (divided into subfolders by date of testing)

The Subconsultant shall review all data prior to any submissions to correct questionable, illegible or incorrect data.

Dye testing field work will be suspended for one week following the first data submission. During this week the data will be reviewed and QC comments will be forwarded to the Subconsultant. The Subconsultant shall modify data collection procedures to address any QC comments. If at any time the data submitted is questionable, incomplete or illegible, the Subconsultant will be asked to verify and correct the data.

If the Subconsultant finds any issues of immediate concern, the HLSS Team should be notified immediately. If the field crew identifies a defect or maintenance issue that requires immediate attention, it must be classified into one of two categories as described below:

- Emergency – any severe defect such as a collapsed pipe segment, major structural defect in a manhole or pipe segment, missing manhole cover or any other defect which may present a hazardous situation or could lead to an improper sewer discharge.
- Priority – any defect or maintenance issue that should be addressed in order to prevent it from escalating to a classification of “emergency.” Examples may include heavy roots, heavy grease, active surcharge, or other similar defects.

In the event that such a defect is identified, the field crew should prepare a map showing the defect location. The field crew must also provide any available field data, including photographs, which will be useful in identifying and locating the defect. All information regarding the defect shall be collected in such a manner that it can be directly imported into the City's GIS system.

VI. Quality Control Review and Criteria

The Quality Control Review of dye testing data includes review of the field form, field map, Smoke and Dyed Water Testing Database entry, photos, and video for each test. For each observation of dye entering the sanitary sewer pipe, the field crew must fill in a row of the field form. The field form is checked to verify that the following columns are filled out correctly for all observations: defect number, address, source type, location, sector and photo number. All columns on the field form must refer to the location where dye enters the sanitary system. See Appendix C for an example of a properly filled out dye testing field form.

If the dye test setup is modified in the field, the field map must include clear notes describing the changes. In order for a revised test setup to pass QC Review, the field map must at a minimum include an explanation of why the test could not be conducted under the original test setup and a description of how the revised setup was able to test the same storm and sanitary sewer assets for potential cross-connections. All dye testing data in the Smoke and Dyed Water Testing Database is reviewed to confirm that this data matches the hand-written information provided on field forms and field maps. For each dye observation in the database, the observation comment box is checked for the following:

- Location of the dye observation in the format “XX ft. downstream of MH ID”
- PACP coding for the dye observation, including clock positions or other information as required by the PACP Guidelines

See Appendix B for additional guidelines on populating dye test data entries in the database. The QC Review evaluates all dye test data for conformance with these guidelines.

For each dye observation, a still photo must be taken using the CCTV camera. All photos are reviewed to verify that they clearly show the exact location where the dye enters the sanitary sewer pipe. In addition, each video is checked for video quality. A video will fail QC review if it is too dark, the video image is blurry or distorted, or the video has too much light causing a reflection of the pipe.